Prior Reclamation Study - Protection of Water Resources
Homestake Mining Co., United Nuclear Corp. and Kerr-McGee Corp.

Submitted in Partial Fulfillment of New Mexico Mining Act
Section 69-36-7 U, Prior Reclamation
Protection of Water Resources

New Mexico Energy, Minerals, and Natural Resources Department
Mining and Minerals Division
Mining Act Reclamation Bureau

Introduction

Purpose of Study

The purpose of this study is to determine if further measures are required to protect water resources from degradation following mining operations at Homestake Mining Company and United Nuclear Corporation Mines prior reclamation sites near Ambrosia Lake, New Mexico and Kerr-McGee Corporation sites near Church Rock, New Mexico. The sites are tabulated in Table I. These companies are applying for release from further obligations pursuant to Section 69-36-7 of the New Mexico Mining Act and Section 5.10 of the New Mexico Mining Act Rules.

According to Section 69-36-7 U of the New Mexico Mining Act and Section 5.10 of the New Mexico Mining Act Rules an operator may apply for release from further requirements of the Act if the director of the State of New Mexico Mining and Minerals Division determines that reclamation measures satisfy requirements of the Act and substantive requirements for reclamation pursuant to applicable regulatory standards. "Reclamation" is defined by the Act as "the employment during and after a mining operation of measures designed to mitigate disturbance of effected areas and permit areas and to the extent practicable, provide for the stabilization of a permit area following closure that will minimize future impacts to the environment from the mining operation and protect air and water resources."

Surface Water Resources

There are no perennial or intermittent streams in the area of Ambrosia Lake. All surface runoff drains to ephemeral water courses and eventually into the San Mateo Drainage (Homestake, 1994). While uranium mines were operating in the area the San Mateo Creek, a tributary of the Rio San Jose, gained flow as a response of mine discharge. This water seldom reached the Rio San Jose because of seepage into the alluvium. The San Mateo Creek is now directly recharged from ground water (Brod, 1979). Before uranium mining the Pureco River was also an ephemeral stream. During mining operations the Puerco River flowed at rates as high as 10 cu ft/sec. The Puerco River is now perennial principally because of municipal effluent discharge (Stone *et al.*, 1983). Water from mine dewatering operations contained elevated levels of radiochemicals and toxic metals. However, there are no lasting impacts on surface water resources because of mine water discharge (Kaufmann et al., 1976). The shallow alluvium in the Ambrosia Lake Area is separated from underlying sandstone units by the impermeable Mancos Shale (Stone, 1983).

Protection of surface water resources with respect to erosion and sediment was accomplished by regrading the area to a stable configuration and reestablishment of permanent vegetation. Post mining topography and vegetation were inspected by Mining and Minerals Division personnel July 13-14, 1995 and will be addressed in a separate report. There were no waste piles of radioactive material left on the surface with the potential to contaminate surface water.

Table I
Prior Reclamation Study Site

Operator	Site	Wet Mine
Homestake Mining Company	Section 13 Mine	Dry
"	Section 15 Mine	Wet
"	Section 23 Mine	Wet
"	Section 25 Mine	Wet (Solution Mined)
"	Section 32 Mine	Wet
United Nuclear Corporation	Anna Lee Mine	Mostly Dry
"	John Bill Mine	Wet
"	Sandstone Mine (Section 34 Mine)	Wet
Kerr-McGee	Church Rock 1 Mine	Wet
"	Church Rock 1East Mine	Wet
"	Church Rock 2 Mine	Wet

Groundwater Resources

Regional Aquifer's

Figure 1 (Stone *et al.*, 1983) shows the geologic section in the Raton Basin. The City of Gallup derives most of its drinking water from the Gallup Sandstone. The San Andres Limestone and Glorieta Sandstone combine to form a significant aquifer along the southern margin of the San Juan Basin between Grants and Gallup. The Cities of Grants and Milan obtain water from this Aquifer. The Village of San Mateo relies primarily on the Point Lookout Sandstone for it's drinking water supply. The Morrison Formation, in which uranium mining took place, is the source of the public water supply for the Village of Crownpoint (Stone *et al.*, 1983).

Regional Groundwater Flow

The geology of the San Juan Basin is characterized by alternating strata of high and low hydraulic conductivities and, therefore, the major component of ground water flow in the San Juan Basin is through the higher conductivity units. The amount of vertical movement between aquifers is difficult to determine using available data. However, differences between vertically adjacent aquifers suggest that leakage rates through intervening shale beds are very low in most areas (Stone *et al.*, 1983). The geologic section in Figure 1 shows the probable direction of flow through confining beds. Note that the flow direction of leakage from the Morrison Formation is downward.

Generally, ground water flow within aquifers is from topraphically high outcrop areas toward lower outcrop areas. Much of the recharge to aquifers in the basin occurs on the flanks of the Zuni, Chuska and Cebolleta Mountains. Also contributing to the regional flow systems is recharge from high areas along the northern and northeastern basin margins, including the San Juan Mountains in Colorado. The San Juan valley in the northwest part of the basin and tributaries of the Rio Grande such as the Rio Salado, Rio Puerco and Rio San Jose in the southeast parts of the basin are the main discharge areas for the basin. Less important in terms of volume of outflow is the Puerco River near Gallup. Ephemeral stream channels filled with alluvium are the principal sources of groundwater recharge at higher elevations and the principal locations of discharge at lower elevations. The alluvial cover usually conceals evidence of discharge. Occasionally, white salt or alkali deposits associated with small-yield springs reveal groundwater discharge. Most discharge to alluvial channels is lost by evapotranspiration. However, some also moves as subsurface flow (Stone *et al.*, 1983).

The stratigraphic units of the prior reclamation sites in the vicinity of Ambrosia Lake are shown in Figure 2 (Kelly, 1963). This figure shows the Cretaceous system of the Mancos Shale and Dakota Sandstone overlying the Jurassic System of the Morrison Formation. Uranium ore was found in the "A" through "D" units of the Westwater Canyon member of the Morrison Formation (Homestake, 1994). Figure 2 shows that the Gallup Sandstone and Point lookout Sandstone Aquifers do not exist in the area of the Homestake and United Nuclear sites (except the northeast corner of United Nuclear's Section 28) and that the Mancos Shale Aquitard isolates the Morrison formation from overlying formations down dip.

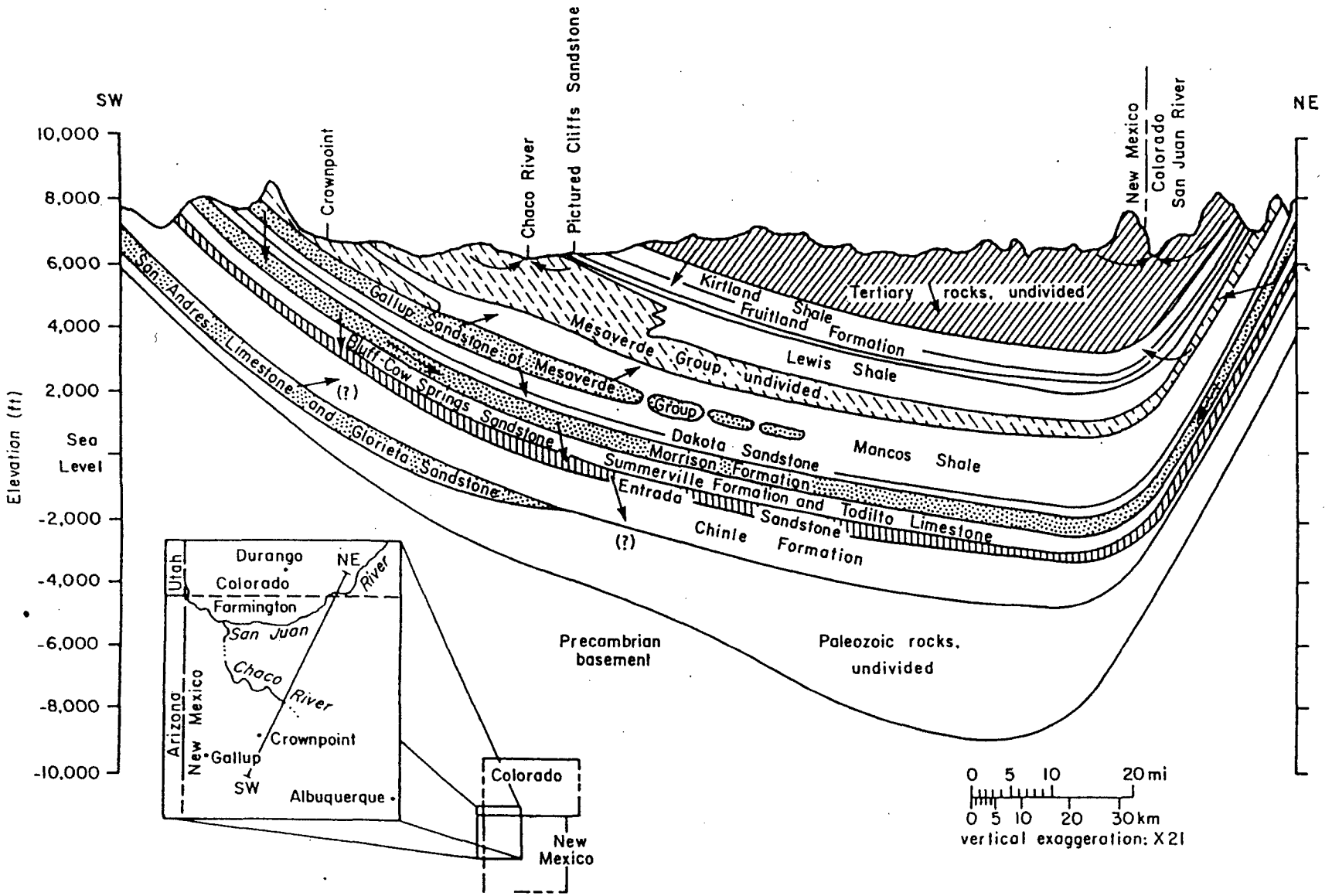

Figure 1 - Generalized Hydrologic Cross Section of San Juan Basin showing major aquifers (stipped), confining confining beds (blank), and directions of groundwater flow (arrows). From Stone et al., 1983

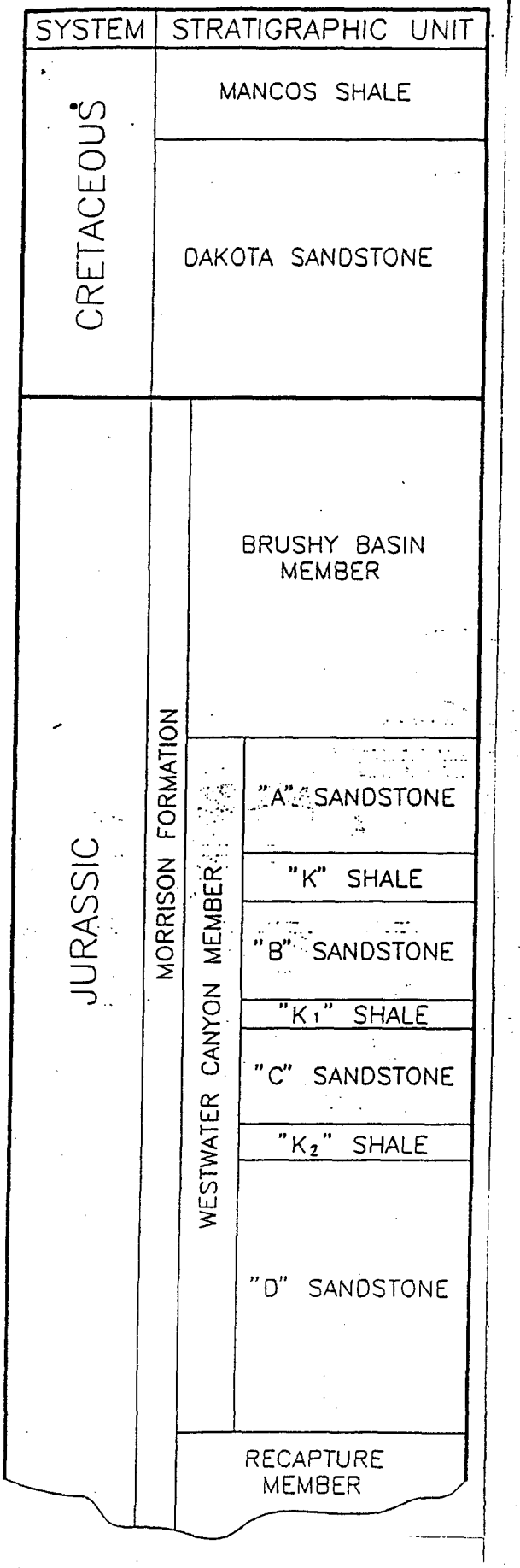

Figure 2 - Divisions of Morrison Formation in the vicinity of Homestake Mining Company prior reclamation sites. From Kelly, 1963

Figure 3 (Stone *et al.*, 1983) shows the potentiometric surface for the Westwater Canyon member of the Morrison Formation. The Morrison Formation is the formation in which mining for uranium took place. This figure shows that the Westwater is recharged from the Nacimento Mountains to the northeast and the Zuni Mountains to the southwest. Figure 4 (Stone et al., 1983) depicts transmissitivity within the Morrison Formation. From Figures 3 and 4 it is intuitive that groundwater within the Morrison Formation in the area of Ambrosia Lake flows primarily to the Rio Puerco discharge area in the southeast, away from Crownpoint. Groundwater within the Morrison Formation in the Church Rock Area flows north, away from Crownpoint, where it discharges into the San Juan River.

Figure 5 (Stone *et al.*, 1983) delineates elevations of the top of the overlying Dakota Sandstone. Figures 3 and Figure 5, show that the potentiometric surface in the Ambrosia Lake and Church Rock areas is well below the top of the Dakota Sandstone. Potentially contaminated water from the Morrison Formation, therefore, lacks potential to migrate to aquifers above. Also, according to Bill Ganus (1995) water levels within the Morrison Formation appeared to be stabilizing at an elevation of approximately 6600 feet (below the top of the Dakota Sandstone) after the cessation of mining operations in the Church Rock Area. In addition, if one considers the thickness and impermeability of the Mancos Shale that overlies both the Morrison Formation and the Dakota Sandstone it becomes oblivious that water within the Morrison Formation is confined to the Morrison Formation.

Mining Impacts on Ground Water Quality

Regional impacts of uranium mining on groundwater were associated with mine discharge, tailings pond effluent, solution mining and collapse of underground workings. Water quality was altered near mining operations because oxidation at the mine face makes some radionuclides soluble. As water levels in the mines return to their original levels it is expected that oxidation of uranium will cease and that water quality will return to pre-mining levels. The mines in which mining occurred in zones of saturated ground are indicated in Table I. All prior reclamation site vertical shafts were backfilled and capped with concrete to prevent contamination of groundwater by surface drainage. The Gallup Sandstone was sealed from the shaft at the Kerr-McGee sites near Church Rock (Ganus, 1995).

Mine discharge from mine dewatering operations was sometimes injected underground as well as discharged in surface drainages. Water pumped from mines often contained elevated levels of radiochemicals and toxic metals (Kaufmann *et al.*, 1976). Although some water pumped from the mines was used for milling, much of the water was injected underground, used for other purposes, or discharged into arroyos. The quality of mine water discharged underground has been monitored by the U.S. Environmental Agency and the New Mexico Environment Department for impacts to groundwater resources since 1977. However, natural groundwater flowing into mine workings and which reenters the ground by gravity flow is exempt from WQCC discharge plan requirements.

Water discharged with mill tailings contained high levels of radioactive and other chemicals added or mobilized during the extraction process. The quality of discharged process water was monitored by the U.S. Environmental Protection Agency and the New Mexico Environment Department for adherence to National Pollutant Discharge Elimination System and the New Mexico Water Quality

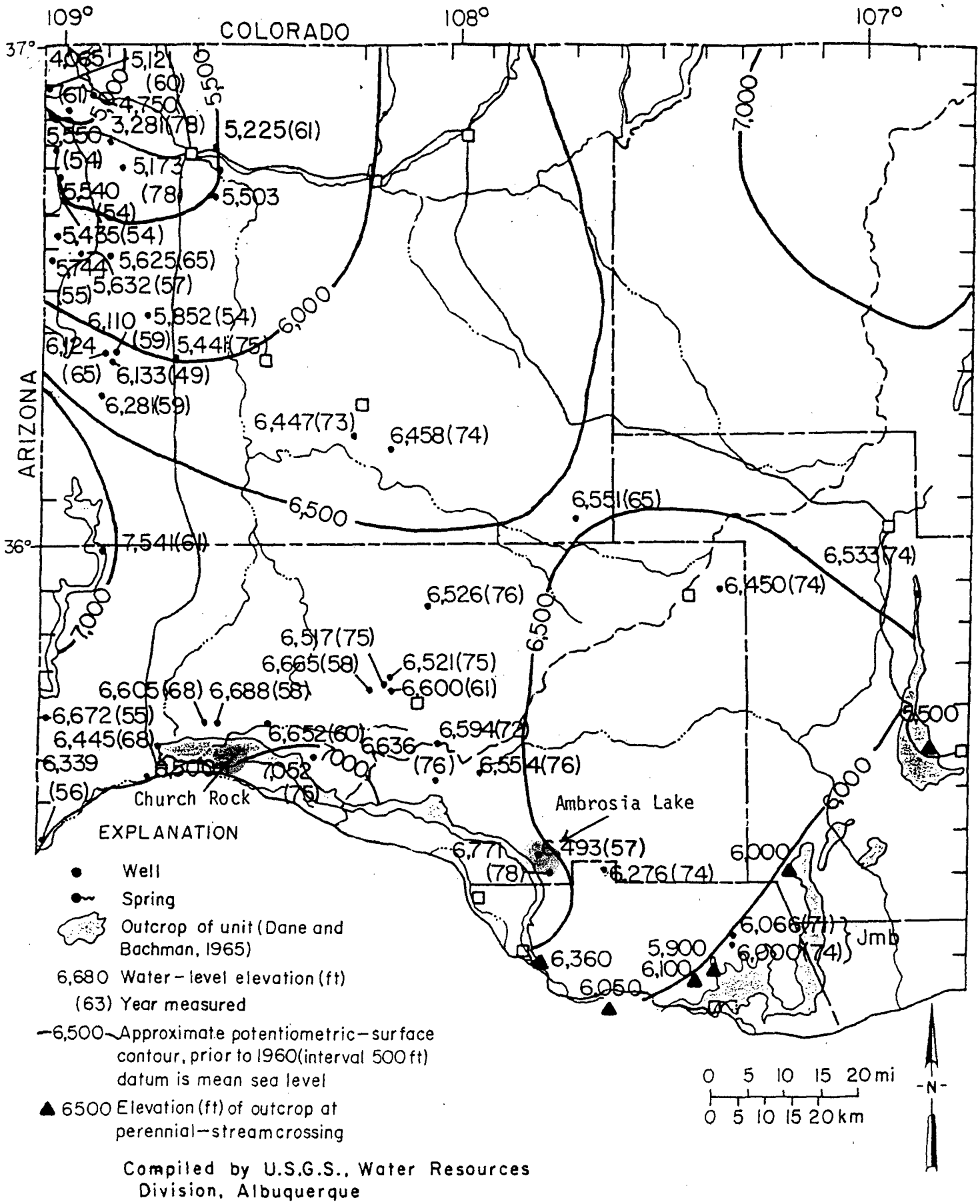

Figure 3 - Water level altitudes and potentiometric surface for Westwater Canyon Member of Morrison Formation. From Stone, et al., 1983

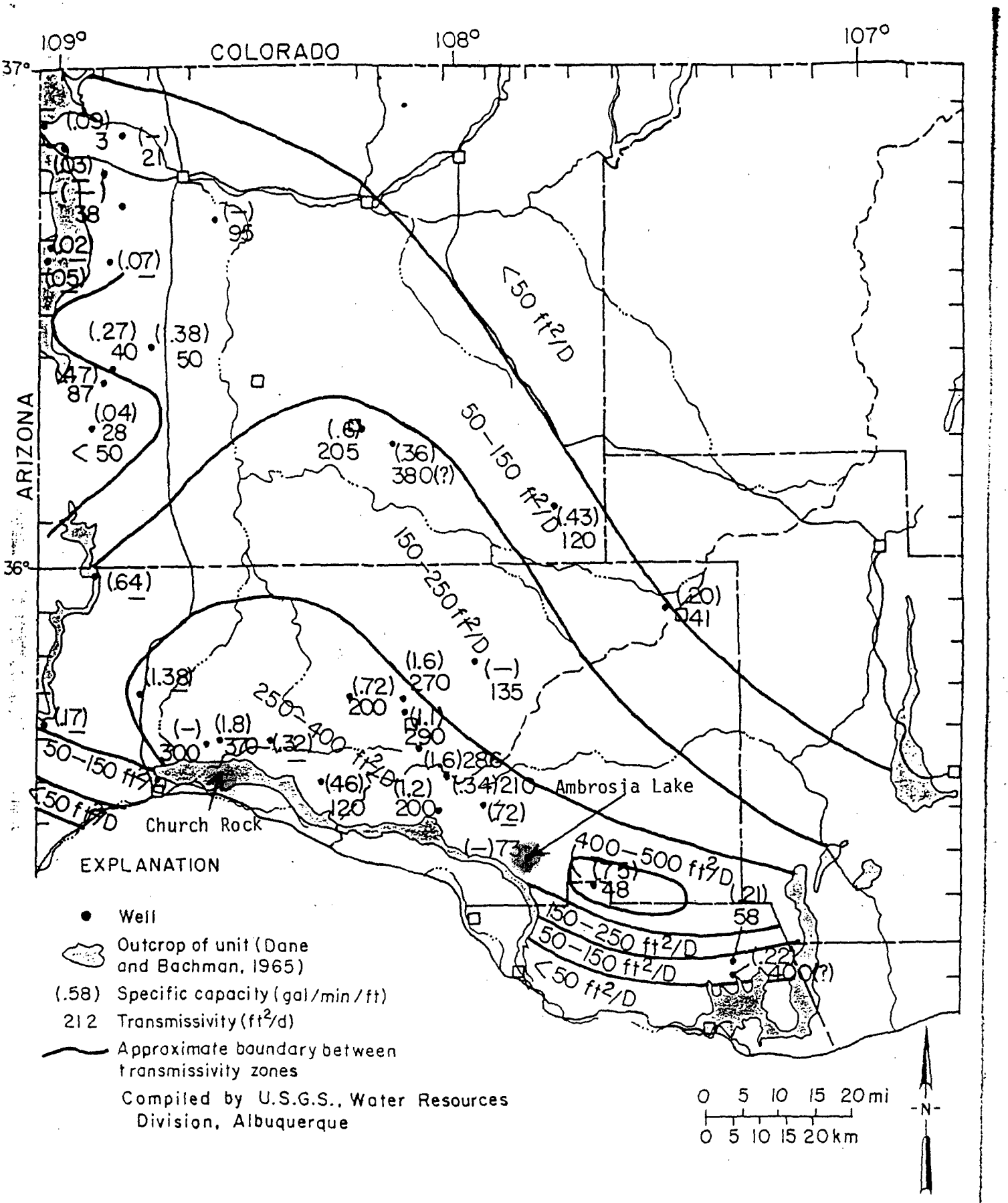

Figure 4 - Transmissivity ans Specific Capacity of wells in Morrison Formation. Frone Stone, et al., 1983

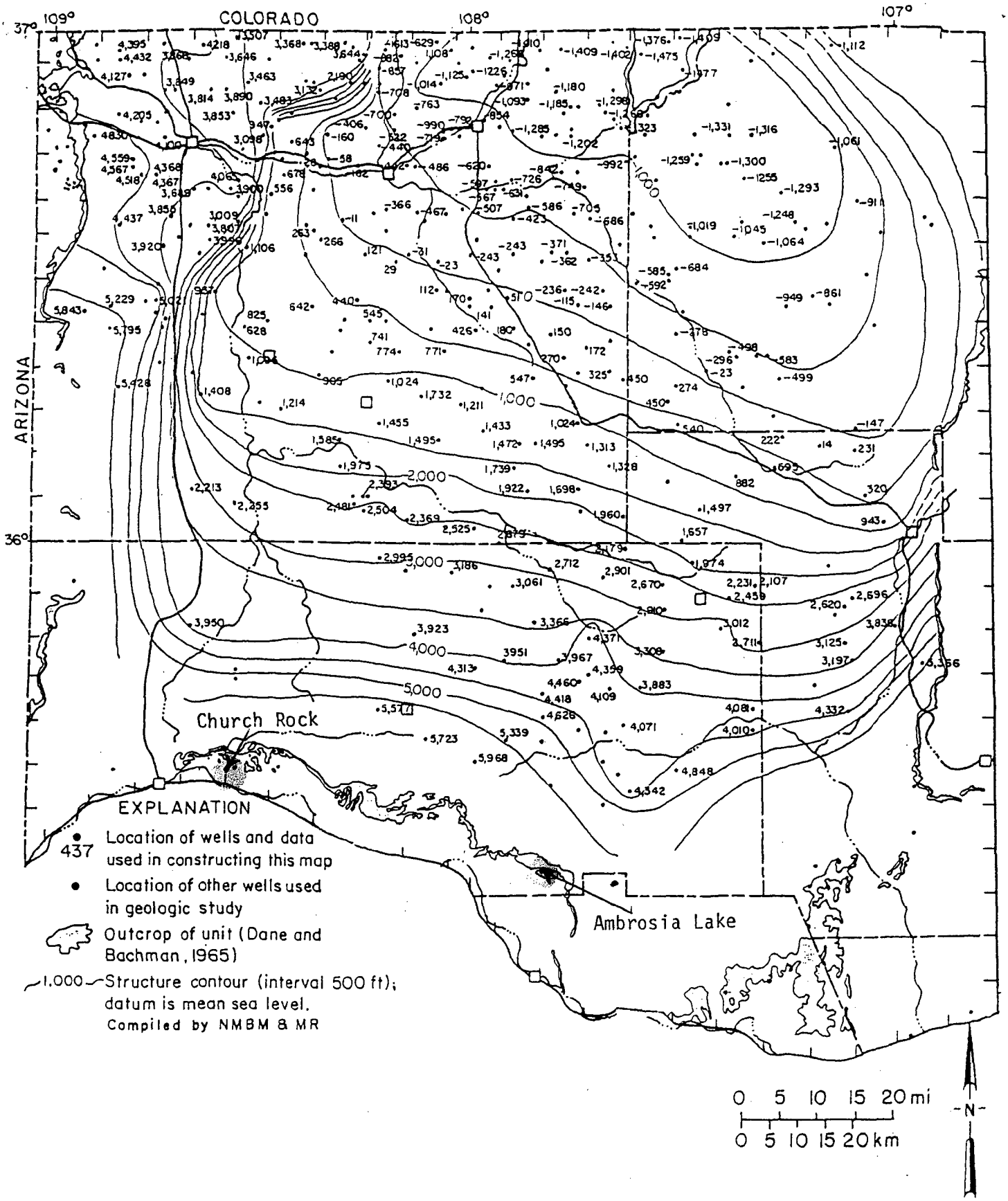

Figure 5 - Elevation of top of Dakota Sandstone structure. From Stone, From Stone, et al., 1983

Control Commission discharge regulations after 1977. Water used in the milling process and discharged with the mill tailings either evaporated or infiltrated to recharge shallow aquifers. Kaufman et al. (1976) said that about 30% of the tailings water in the Ambrosia Lake area infiltrated causing high levels of selenium in shallow groundwater near the tailings piles. Groundwater contamination associated with tailings dams is regulated by the Nuclear Regulatory Commission and is, therefore, beyond the scope of this study.

Collapse of underground workings has probably caused some deterioration of water quality in the Morrison Formation near Ambrosia Lake by providing a connection to the overlying Dakota Sandstone. In the Ambrosia Lake Area the Dakota Sandstone contains higher concentrations of dissolved solids than the Morrison (Cooper and John, 1968). There nothing mine operators can do to prevent further collapse of underground workings. However, sandstone has an especially high swell factor of 66 percent (Caterpillar, 1991). Consequently, it is unlikely that subsurface subsidence will extend to aquifers above the Dakota Sandstone.

At the Homestake Section 23 Mine uranium was extracted by in situ leaching. Although this method eliminated many water resource impacts associated with conventional mining, it caused some new ones, such as control of the leaching fluid and cleanup of the Morrison Aquifer after leaching ceased. Impacts on groundwater by solution mining are regulated via groundwater discharge plans by the New Mexico Environment Department.

Continental Oil Company personnel, after conducting a literature search on the mobility of radium in groundwater systems, concluded that dispersion, ion exchange, and radioactive decay prevents extensive migration of excessive radium concentrations that might persist in the immediate area of a mine (Jensen W.M., 1978). These geochemical processes, by which uranium minerals were deposited in the first place, probably limit migration of uranium as well as other toxic substances.

Mining Impacts to Ground Water Quantity

During mining operations a large quantity of freshwater was pumped to keep the mines dewatered. Much of the water needed for uranium mining and milling was provided by mine water discharge. In addition water for milling was produced from wells completed in the Glorieta Sandstone - San Andres Limestone near Grants and wells tapping the Morrison Formation north of Laguna Dewatering caused large declines in water levels in the Morrison Formation (Lyford *et al.*, 1980). Pumpage of water for uranium exploration drilling also caused water-level declines in the Gallup Sandstone. It is expected, however, that water levels will return to premining levels with the cessation of mining operations.

Summary and Conclusions

Protection of surface water resources with respect to erosion and sediment was accomplished by regrading the area to a stable configuration and reestablishment of permanent vegetation. Post mining topography and vegetation were inspected by Mining and Minerals Division personnel July 13-14, 1995 and will be addressed in a separate report. There are no waste piles of radioactive material left on the surface with the potential to contaminate surface water.

Uranium mining took place within the Morrison Formation and the Morrison Formation is the source of the public water supply for the Village of Crownpoint. However, water within the Morrison potentially contaminated by mining operations would most likely be confined to the Morrison Formation. The flow of groundwater within the Morrison Formation in the area of Ambrosia Lake is to the southeast and in the area of Church Rock to the north, away from the community of Crownpoint.

The quality of water discharged into surface arroyos has been regulated by the U.S. Environmental Protection Agency and the New Mexico Environment Department for adherence to National Pollutant Discharge Elimination System and the New Mexico Water Quality Control Commission discharge regulations after 1977. The quality of water discharged underground has been regulated since 1977 by the New Mexico Environment Department according to respective groundwater discharge plans. Mine dewatering has caused large declines in water levels in the Morrison Formation and the Gallup Sandstone. It is expected, however, that water levels will return to premining levels with the cessation of mining operations.

It is expected that oxidation of uranium minerals will cease and water will return to premining quality as groundwater recovers to premining levels. Geochemical processes such as dispersion, ion exchange, and radioactive decay may prevent extensive migration of excessive radium concentrations that might persist and limit migration of other toxic substances.

No further reclamation measures, that fall within the regulatory authority of the New Mexico Mining Act, are required to protect water resources from degradation following uranium mining at Homestake Mining Company and United Nuclear Corporation Mines prior reclamation sites near Ambrosia Lake, New Mexico and Kerr-McGee Corporation sites near Church Rock, New Mexico.

References

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Stone et al. (Stone, W.J., Lyford, F.P., Frenzel, P.F., Mizell, N.H. and Padgett, E.T.) 1983, Hydrology and Water Resources of the San Juan Basin, New Mexico, New Mexico Bureau of Mines and Mineral Resources, Hydrologic Report 6.

Ann-Lee Mine 7/13/95

Shaft Reclamation

4' Concrete Cap ≠ 20' x 20'

Wet Mix

Seeded -

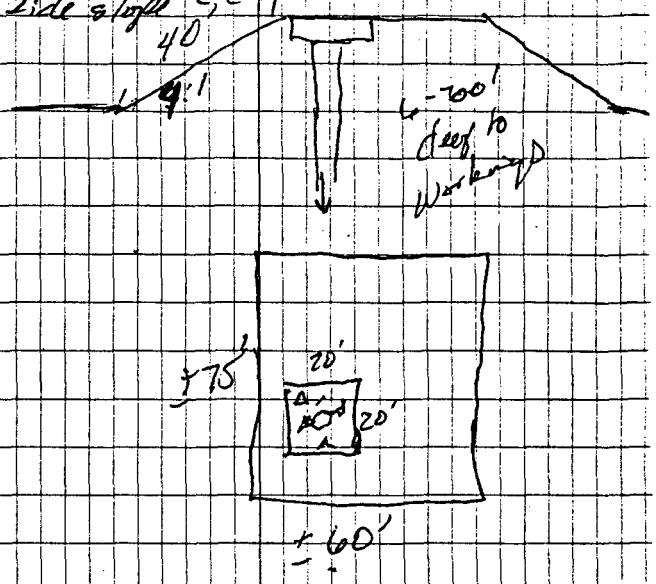
Ultra - Ambrosia Lake Site

Photos:

① From Ground level to Mound

(2 & 3) Top of Site w/ Concrete Cap

(4 & 5) Side slope - east



Index of Correspondence

Date	Addressee	Subject
06/21/95	Kathleen Garland/From: Juan Velasquez	Prior Reclamation Inspection Request Fee Payment

Index of Correspondence

Date	Addressee	Subject
07/16/93	Anita Lockwood/From: Juan Velasquez	1993 NM Mining Act Owner/ Operator Info. Requirements
06/21/94	John Lingo/From: Juan Velasquez	Updated NM Mining Act Owner/ Operator Information
06/29/94	John Lingo/From: Juan Velasquez	Updated NM Mining Act Owner/ Operator Information
06/29/94	John Lingo/From: Juan Velasquez	Updated NM Mining Act Owner/ Operator Information
08/25/94	Juan Velasquez/From: John Lingo	Response to Decision of NM Mining Act Owner/Operator
08/26/94	John Lingo/From: Juan Velasquez	Request for Inspection of Certain Reclaimed Existing Mining Operations
09/28/94	MARB File/From: Holland Shepherd	Meeting w/UNC Concerning Status of Mining Properties in N.M.
10/19/94	John Lingo/From: Juan Velasquez	Reply to August 25, & Various August 31, 1994 Letters